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ABSTRACT

The impact of programed instruction on the educational system has been minimal quantitatively and qualitatively. In the interface between education and programing there are serious weaknesses in the design of materials, severe problems in the economics of design and use, and an almost insurmountable gulf between the philosophy or point of view on which programing is based and the present thinking of most school systems. Two areas in which the technology needs further development are in the analysis of the structure of knowledge and in the approach to cross-curricular skills such as creativity, critical thinking, and inference techniques. The unnecessary duplication of effort which is common in programing instruction today has led to a waste of financial and human resources. There seems to be a philosophical conflict between the empirical approach of the adherents of programed instruction and the idealism of the process-oriented educational philosophers. (Author/JY)

PROGRAMING AND PROGRAMED INSTRUCTION

by

by Susan Meyer Markle*

The programing of instruction is a process of designing instructional materials and systems which results, if followed to its full extent, in a rationally constructed and empirically validated product or set of procedures. The process consists of five basic steps:

1. Determining the objectives of instruction in order to, a)describe an observable performance of a student who has completed the instruction, b)make clear the conditions under which students will demonstrate mastery of the material and c)establish a standard of acceptable performance.

2. Designing and evaluating the "criterion measures" which would rate students individually on a scale of attainment of the desired knowledge or behavior.

3. Testing potential student groups to learn their characteristics which will determine, in turn, the design of the lesson.

4. Selecting instructional media and preparing instructional material in draft form.

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5. Refining the product through try-outs with individual students until effectiveness reaches satisfactory levels. This process is then continued with increasingly large groups of students until effectiveness proves satisfactory in approximately "real" situations. The materials are finally "validated" by publication of a complete description of their performance in terms of their effect on specified groups of students under carefully described conditions.

Programed materials, therefore, cannot be identified by any single format. The only observable distinguishing characteristic is a product description, providing the consumer with the complete set of objectives, matching criterion measures,and data, drawn from research with students, which support the claims for the teaching effectiveness of the materials.

The impact of programed instruction on the educational system has been minimal quantitatively and qualitatively. "Software" is one very important problem: when considered in relation to their proposed intent to truly individualize instruction, the quantity of programed materials available to the schools is still miniscule. On the other hand, schools generally do not require effective products and methods because administrative innovation has not proceeded at the same rate as instructional innovation.

In sum, programed instruction is not fully ready for the schools and the schools are even less ready for programed instruction. In the interface between education and programing there are serious weaknesses in the designing of the materials, severe problems in the economics of design and use, and an almost insurmountable gulf between the philosophy or point of view on which programing is based and the present thinking of most school systems.

Weaknesses in the technology. A significant problem in the design stage is the selection of appropriate objectives. In industry and in military organizations, where programing has had considerable success, there exists an ultimate reference against which the appropriateness of the objectives can be tested, namely the job for which the man is being trained. This is not to say that such job descriptions are necessarily simple, especially when interpersonal relations are involved, such as with salesmen or management trainees. However, where such a job exists as a reference against which instructional decisions may be validated, lean programing makes obvious sense. One can determine standards, which may include efficiency as well as effectiveness (see D. Markle, 1967b), and build instruction from this endpoint backwards. In the educational setting, with no such outside reference, the instructional designer is usually thrown back upon the more or less illogical content coverage found in existing texts and syllabi. With a few possible exceptions in some of the curriculum projects now underway, this content coverage is an irrational patchwork of topics bearing little relation to what students have already learned or to what they will need to know in future courses. The fractionation and lack of articulation between and within subject matters has been noted many times; the problems created are serious for teachers and

instructional materials developers who have to "cover" material. For programers, oriented to student performance, the problems are critical. Buried in the patchwork are two areas where the technology is not yet mature.

The first area we might call the "structure of knowledge", in the sense intended by Bruner (1960) and others. It hardly needs saying that we have no firm grasp of what happens to students when various elements in the mathematics or science or social science curricula are moved up or moved down in the academic progression. For instance, on a speculative note, if set theory is taught in the first grade, would this not in some way affect the ability to form logical categories -- which is included in the "process approach" to science several grades later? Or might it not interfere with the child's ability to grasp the essentially illogical categories of traditional grammar when he meets them in seventh grade? No research designs exist at present for expanding the measuring procedures used in validating programed materials to take account of these possible transfer effects. No pressure exists to do so, of course, since the teaching profession does not itself do so. What I see needed here is some long-term development studies paralleling some of the pioneer work done in individual language development, where individual children are intensively followed over long periods. Such an approach is implicit in the orientation of operant conditioners who tend to study single organisms intensively for long periods of time. It does not generally exist in educational research, where a developmental study is more likely to include a sampling at one point in time of different individuals at different ages. (The work of Piaget and Gesell illustrate this latter approach; Terman's studies of the gifted is a rare example of the former.)

Programers have begun work on the types of analytical procedures needed to improve objectives. There are, however, no published papers or results as

yet from the work of persons like Philip Tiemann and myself, Richard Anderson at the University of Illinois, Urbana, or James Popham and Eva Baker at the University of California, Los Angeles. Similar in intent, but not fully adequate to this purpose, is Gagné's analysis (1965). The absolute necessity of new techniques of analysing knowledge has become apparent from the weaknesses in the kinds of objectives which predominate in available educational programs. In other words, there must be a way to attack rationally the question of what ought to be taught. But the technology for deriving better objectives does not yet exist in educational subjects to the same extent as in task analysis for industrial objectives.

A second and related area in which the technology needs further development is in the analysis of what might be called "cross-curricular skills", among which would be "critical thinking", "inference techniques", "creativity", and others. Skinner (1968) points out that the attempt to teach thinking, in the sense intended by proponents of discovery learning, often leads to inefficient teaching of the subject matter being "discovered". The conflict is real, in that students undoubtedly should be led to think for themselves and yet the method of discovery often leaves them with precious little knowledge to think about. A few direct attacks on the problems of teaching thinking or creativity (James Holland's program on inference, Richard Crutchfield's program on critical thinking, and Sidney Parnes' work on creative analysis) have had little effect on the design of programs aimed at subject-matter knowledge. The technology of empirical testing -- the revision cycle based on student errors -- almost guarantees dropping any frames and sequences which require much thinking skill, since the error rate generally goes up. As a consequence, remarkably little is known about how to produce such skills reliably.

The computer as a magnificent branching tool comes to mind in discussions of teaching thinking. The prognosis for computer assistance with this problem would be more hopeful, however, if we had a better software technology for producing thinkers. Most of the "dialogue" mode software now used as illustrations of what computers will be able to do in teaching thinking are really nothing more than tests of skills already learned.

The technology of analysis is incomplete in these two areas. Until these puzzles can be solved, the products of the programing process will not come up to the fond hopes of the educators. It is, of course, readily apparent that present educational techniques are not achieving such results either, although educational goals promulgated by school systems would lead us to think they are. The average educator, unconcerned by the gap between the goals claimed and any evidence that students are achieving such goals, tends to reject as beneath consideration products which, if appropriately administered, can reliably achieve the lesser objectives claimed for them.

Economic problems. There have been many references in the literature to the remarkable amount of development time invested by programers in producing reliable products. Estimates of 50 to 75 hours per hour of student time are frequent, even for the so-called "simple" skills of military and industrial training. The economic advantages of such an extensive investment of programer time have been calculated in an industrial setting where students are paid while learning and production losses due to ineffective instruction can be at least estimated. (K. Brethower, 1966. See also, Rummler et al., 1967.) No such economic basis for improving instruction has been agreed upon for education.

A short perusal of a bibliography such as Hendershot's (1967) reveals that most programs, including those with a sound research basis, are being

sold to schools at prices competitive with traditional textbooks. Some programs aimed at the industrial market appear to have more meaningful price-tags. Given the small distribution of any programed material whatever in the schools at present, as mentioned in the article, and the small per unit price, it is indeed small wonder that so few fully researched effective products have appeared on the market.

The financing of the capital development required is still problematical. Fractionated school districts certainly cannot afford it, nor do they generally have either the talent or technical knowledge to produce such materials. Publishers, accustomed to reimbursing authors by royalties based on sales, are wary of the immense investment required by the research. Authors do not recover their investment of time (I have calculated a returned wage of 50 cents per hour on one of mine) and the financial woes of the programing companies which concentrated solely on the school market is well-known.

Considerable discussion of government priming of the pump has taken place (see Subcommittee on Economic Progress); at least one of the regional laboratories backed by the Office of Education is officially in the business (see Popham, 1967). There is, of course, also the risk capital available in the "education industry", the effects of which at the moment are unknown. Much has been said about the concentration of that industry on glamorous hardware; it is well known that software, if available at all for these new machines, is rarely a product of behavioral technology at a level of sophistication consonant with the hardware.

As one wit said "If education had produced the Edsel, they still wouldn't know it was a failure." It is difficult to see how appropriate pricing of effective products backed by expensive and extensive research can be fostered when the consumer is apparently incapable of making the appropriate discriminations.

Economist Donald Paden (1967) has theorized that, at least at the college level, a severe problem exists in providing the resources to enable instructors to take advantage of the new technology. A professor who is caught up in the cycle of frequent lectures, last-minute construction of tests, and manggement of increasing numbers of students has, in the publish-and-perish world, little time and less incentive to invest the required effort in instructional improvement. He talks of the notion of "critical mass" -- of developing enough replicable (though not programed) instruction via film, TV, tapes or whatever, so that a course may be, in a sense, self-opperating or run by assistants. When, for instance, a sufficient number of lectures are on videotape, the instructor is then freed to devote time to improving them, making do with less than perfect performances in most lectures while he upgrades one at a time. To do so, the instructor nedds not only the time released by his previous investment of time but also considerable technical help in the production process. Paden has also emphasized the impossibility of the educational system repeating this experiment on every campus in every university, because of the cost.

Such an investment of capital resources and talent suggests that the resulting improved products should command wide distribution. In reality, university instructors tend to give little consideration to using other instructors' validated lectures, though they feel no qualms about adopting texts. The widely used phrase "not invented here" (the NIH syndrome) puts the finger on the probably cause -- the ego satisfaction of the instructor in his role as purveyor of information and his unfamiliarity with the role of manager of learning. This phenomenon is parallel to the still-prevalent fear of teachers at lower levels of the educational system that programed instruction will somehow replace them. The economic loss represented by the cottage-industry approach to instruction -- every professor across the country writing the same formula on the blackboard for thirty students in front of him -- has the parallel in what I call the "prima donna" approach to course development, in

which neither administrator nor department head nor even colleagues teaching later courses would presume to tell a professor what his course should achieve.

The "critical mass" phenomenon was obliquely mentioned on p. 17 of the article. The significant capital investments in education lie in buildings and wages for the staff, not in teaching materials. When the number of students increases in such a system, the system adds new classrooms and new staff. Little thought is given to incrasing the efficiency of the system's use of its resources. Efficiency cannot be calculated with any meaningful accuracy, however, until effectiveness is established, and this basis is still lacking. Until a sufficient number of products exist to enable a shift to a criterion-referenced system, there is little incentive for educational systems to endure the pains and problems of operating partially on time-accounting and partially on effectiveness-accounting. Until there is a discriminating market for fully researched materials, it is unlikely that many will be developed. The result is a stand-off between these two realities. It seems, in concurrence with the findings of the Harvard University Program on Technology and Society (1967) that, barring some revolutionary development, especially in the administrative area, substantial and sophisticated use of educational technology is not likely to occur in the near future.

Philosophical issues. It is not clear at the moment how many of the arguments bandied about are a function of a true difference of opinion and how many are purely a function of the preferred language of each side. The use of the term "technology", the emphasis of operant conditioners on "behavior" and especially upon "control" have undoubtedly created violent reactions where the intent and even the methods would be fully acceptable to the opposition. Any attempt to "improve" instruction is, of course, implicitly an attack upon its present state and is so interpreted by its practitioners.

There does, however, seem to be a basic divergence in point-of-view between the tough-minded empiricism of the product-oriented programing fraternity and the tender-minded idealism irrespective-of-evidence of the process-oriented educational philosophers. Skinner (1968, p90) points out again, as he has before: "We fear effective teaching, as we fear all effective means of changing human behavior." The technology of instruction, based on a scientific and experimentalist approach to human behavior, will probably remain in conflict with other positions for quite some time. It remains to be seen whether its existence will, as Mesthene suggests technology can (1968), determine a change in the value system and administrative organization of the school system or whether the "educational establishment in the United States /is so/ ideally designed to resist change " (Harvard Program, 1967) that the technology itself will be kept outside the doors.

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